BUILDING TECHNOLOGY file

CSIRO

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Tel (03) 9662 7500, Fax (03) 9662 7555
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Number Three
June 2001

Condensation on internal surfaces is the cause of unsightly mould growth in houses and of water collecting under and dripping from factory roofs. However, it often occurs within the building fabric where it may not be so obvious. This may be of greater consequence, leading to decay of timber and otherwise threatening the structural integrity of the building. Ironically, this interstitial condensation can be the result of incorrect use of thermal insulation intended to stop surface condensation.

Condensation

Condensation is sometimes unavoidable

WHAT IS CONDENSATION

Condensation arises because warm air can hold more moisture than cold air. For example, air at 25°C can hold about 20 grams of water per kilogram of air. This is its maximum water content so it corresponds to 100% humidity. If air in this state is cooled to 15°C, then its maximum water content falls to about half this value and about 10 grams of water must condense out of each kilogram of air. This will occur as a fog of liquid droplets if the air is cooled as a mass, or as condensation on a surface if that surface provides local cooling of the air around it.

The air around us is generally not saturated although it may be warm enough to store a considerable amount of moisture. In this state, its relative humidity is less than 100%. However, if this air is cooled below its dewpoint (i.e. cooled to a temperature where its relative humidity would exceed 100%, so that it cannot contain all of the water originally present), then a fog or condensation will occur. If the air is relatively moist then the dewpoint temperature will be not far below the actual air temperature, so condensation occurs readily. Drier air will have a dewpoint which is proportionately low, so that condensation will only occur if it comes into contact with surfaces which are much colder.

The movement of moisture may be controlled in buildings by selectively incorporating elements which inhibit or allow the passage of water vapour as required. A vapour barrier is a material, typically reflective aluminium foil or

polyethylene sheet, which has a high resistance to the flow of water vapour. Where membranes are incorporated in buildings (for other reasons) and high vapour permeance is required, such membranes may be perforated with small holes or be made of a highly permeable material, such as paper or some plastics. Where there is free exchange of air between parts of a building, then it is not possible to restrict the flow of water vapour, and moisture generated in one place will rapidly spread to others. It is therefore possible to have condensation in a cold part of a building caused by water vapour which is sourced some distance away.

A barrier which resists the flow of water vapour

CONDENSATION IN BUILDINGS

The ingredients for condensation are essentially one or more of the following:

- the presence of moisture levels which are too high
- the presence of temperatures in the building fabric which are too low
- uncontrolled flow of water vapour from a source to a region of cold temperature.

Moisture levels within buildings are often higher than outdoors. There are numerous reasons for this. One source of moisture is the ground. Moisture levels in the ground depend upon the local microclimate and on soil characteristics, as well as on the local release of water by activities such as watering. Concrete slabs generally provide a waterproof barrier to ground moisture, but buildings with suspended timber floors (typical of many houses) are quite susceptible to high indoor humidity arising from moist subfloor spaces. In older buildings with inadequate (or failed) damp courses in masonry walls, moisture may be wicked into the building through the masonry. In this case there is likely to be local damage due to the rising damp, but in addition there is a ready source of indoor moisture which may condense elsewhere in the building.

Indoor air can become moist because the occupants and some domestic appliances produce water vapour. Typical quantities of water vapour produced in the home are (in litres per hour):

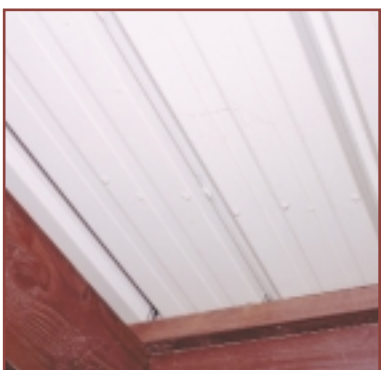
- adult (breathing) 0.1
- hot bath 1.5
- clothes drier 5.0
- hot shower 10.0

Many domestic and industrial appliances such as gas-, oil- and kerosene-fired stoves, burners and heaters produce large quantities of water as a product of combustion. This problem does not arise with flued appliances, where the products of combustion are removed to outdoors.

Low temperatures within a building also arise from a number of different sources and contribute to condensation problems in a number of different ways. Condensation on inside surfaces is generally a winter (or heating season) problem. Insufficiently insulated surfaces become cold enough to fall below the dewpoint of indoor air and condensation necessarily occurs. Sheet metal roofs are particularly susceptible because they 'look up' at a cold night sky. They can fall to a temperature which is actually below the outdoor ambient by a phenomenon known as 'radiation cooling' to the cold sky. In an otherwise well-insulated structure, there may be heat bridges which allow surfaces which are cooled by close contact with outdoors or the ground to exist within the warmer interior space. Typical examples are water pipes, structural steel or aluminium members and window panes and their frames (especially if aluminium). If the interior surfaces of the building have inadequate vapour resistance, condensation may occur within wall, roof or floor structures where the building fabric is colder and may approach outdoor temperature.

In climates where summer humidity is high, condensation can be a summer problem, particularly if mechanical cooling is in use. Water vapour may condense on the outside of the building if it is inadequately insulated or contains heat bridges and is cooled from inside. As in the winter case, water vapour may penetrate the building fabric, this time from the outside, and condense on cold interstitial surfaces.

The cold parts of air-conditioning equipment (such as evaporator lines) are subject to condensation if inadequately lagged and it is possible for wails adjacent to indoor evaporator units, or in the cold airstream from them, to be subject to condensation.



Sheet metal roofs are susceptible

PREVENTING CONDENSATION

Climate

Because climate (particularly temperature and humidity) is a central factor in the risk of condensation, it is not possible to set guidelines which are universally appropriate. In general, areas with higher humidity are more likely to experience problems. In addition, regions with cold, wet winter climates are likely to have problems during the heating season, and regions with hot, humid summer climates are likely to experience problems in their cooling season.

New construction

Severe condensation problems often occur in new buildings, as construction moisture stored in the structure adds to the moisture generated by the occupants and their activities. It takes up to 12 months for new masonry walls, concrete floors and timber framing to dry out. Some drying is to outdoors, but much of the moisture is released to the inside or interstitially where it may be the major cause of a temporary condensation problem.

Good design

Many condensation problems will not arise if the correct steps are taken in the design and construction of the building. Vapour barriers may be crucial and will be specified by the designer if there is a particular risk to some part of the building fabric. They are only effective if installed to an adequately high standard without penetrations or gaps. Vapour barriers are most frequently specified under concrete slabs and under sheet metal roofs, in the latter case often in conjunction with blanket insulation. Often membranes such as reflective foil are specified in buildings for other purposes such as insulation or larking. When used incorrectly they may contribute to a condensation problem by preventing the escape of water vapour from areas where relative humidity levels may become excessive. In general, vapour retarders should be placed on the warm side of building elements within which there is the potential for condensation, and membranes which breathe should be placed on the cold side.

Good design includes providing adequate levels of thermal insulation so that surface temperatures remain high enough to prevent condensation. This may require that particular attention be paid to potential problems with heat bridges in the construction. Higher levels of insulation may introduce unforeseen problems where they are incorporated into construction styles which have previously been relatively immune to condensation. This is because insulation, whilst it keeps some surfaces warm, also keeps other surfaces cold. A simple example is domestic roof spaces. High levels of ceiling insulation mean that roof spaces are colder as they are not heated to the same extent from below. Tiled roofs are relatively immune to condensation as they are well ventilated to outdoors, but incidences of condensation within pitched roof spaces with sheet metal roofs are increasing in line with the trend to higher levels of ceiling insulation.

Condensation on window glass is generally prevented by the use of double glazing. This is expensive but its use is spreading in both domestic and commercial construction. Where climate and building moisture generation dictate, condensation on single-glazed window panes is unavoidable. Poorly designed aluminium frames may similarly be guaranteed to have a condensation problem. Increasing attention is being paid to frame designs which incorporate thermal barriers between indoor and outdoor aluminium sections.

Unflued gas, oil or kerosene heating should be avoided in buildings where condensation problems may be anticipated.

Ground moisture

Excessive watering of lawns and garden beds close to buildings is a potential cause of indoor condensation problems. Buildings sited in areas which are inherently very wet are also likely to experience problems. This may include buildings built into the sides of hills where the watertable may be very close to ground level. Leaky roof gutters and leaking water pipes are other obvious sources of excess ground moisture.

Use exhaust fans in bathrooms

Ventilation

Ventilation is an effective way of removing moisture generated within a building and keeping the relative humidity low. Exhaust fans should be used in bathrooms and laundries at any time when moisture is being produced. Electric clothes driers should be vented to outdoors. With some models, permanent vents to outdoors can be fitted. With units which vent only through the front door, the laundry window should be opened and the connecting door to the rest of the building should be closed whilst the drier is in operation. Range hoods should be used in kitchens as moisture is generated not just as

part of cooking, but also as a combustion product from the gas burners in cooktops and ovens.

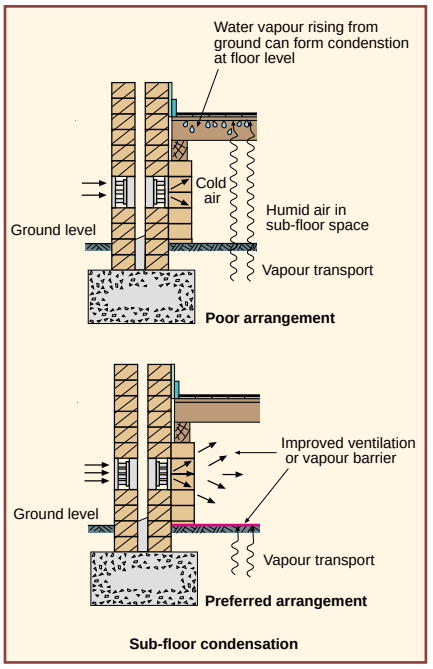
Condensation can occur in subfloor spaces where there is inadequate ventilation. This may lead to decay of timber framing and flooring. Subfloor spaces should be adequately ventilated. Where serious problems occur, a vapour barrier at ground level may also be required.

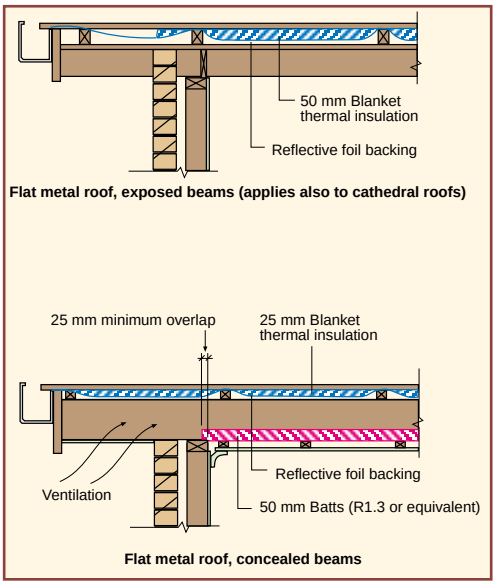
Condensation under metal deck roofs which are not insulated from the space below (which may be a roof space) is a common problem. In commercial and industrial buildings where significant amounts of water vapour are generated by work activities, increased ventilation to outdoors is likely to be of assistance. It is a common practice in domestic and commercial construction to ventilate bathroom, laundry and kitchen areas into the roof space from where it is assumed the moisture will dissipate. However, where there is an uninsulated sheet metal roof, condensation on its underside is a likely occurrence. It is desirable to have fixed ventilation at eaves or gable ends for such roofs and to ensure that exhausts into the roof space area are ducted direct to outdoors.

Rooms such as bedrooms which experience condensation problems in winter generally benefit from small continuous amounts of ventilation through partially opened windows. Ventilation in this way is at some energy cost as the building will either be colder or more expensive to heat.

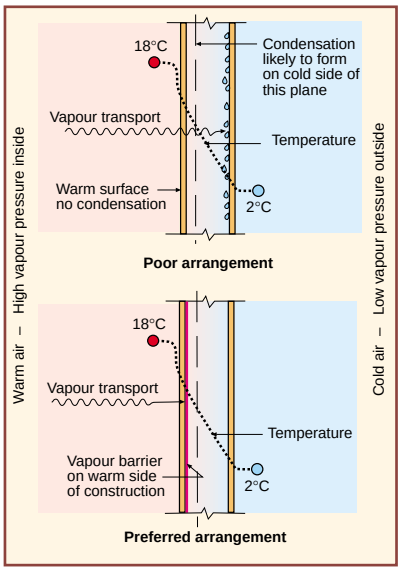
Heating

Condensation on internal walls and ceilings in winter may be greatly reduced by keeping internal temperatures higher by additional heating. As with ventilation, this is generally more beneficial if it is continuous and will necessarily entail higher heating costs.





Condensation control relies on good design detail



Compiled and published by the CSIRO Building, Construction and Engineering, Building Information Resource Centre
PO Box 56, Highett, Vic. 3190, Australia, Tel (03) 9252 6378, Fax (03) 9252 6243, www.dbce.csiro.au